Major	Energy Engineering		
Master's programme	AERODYNAMICS AND AEROACOUSTICS		
Master's Code	AA		
Qualification awarded	**Master's degree in Energy Engineering**		
Programme director	**Damien BIAU (damien.biau@ensam.eu)**		
Mode of study	*Level of qualification*	*Field of study*	*Language of study*
Full time	**Master ISCED 7**	**Engineering ISCED-F-07**	**French and English**
ECTS	*Campus*	*Length of programme*	*Specific arrangements for recognition of prior learning*
60	**ENSAM - Campus Paris & Sorbonne Université – Campus Jussieu**	**1 year (from September to September)**	**No**
Keywords	**Engineering, energy production and transport, aerodynamics, fluid mechanics, Navier-Stokes equations, numerical simulations, high-performance computing.**		

Admission requirements

Type	Level	Way
French proficiency	**Level B2**	**Certificate**
Previous degree	**First-year of Master's (M1) minimum, or equivalent, in Engineering**	**Certificate of achievement**

Applicants interested in the AA programme must follow the online procedure and adhere to the schedule.

https://artsetmetiers.fr/en/formation/master-admissions

Overall objectives

Fluid mechanics describes the macroscopic motion of fluids, building from first principles of classical physics and thermodynamics. Modern fluid mechanics is a very active research area, driven by its fundamental or curiosity driven research interest as an exemplary complex systems, and by its extreme importance in natural and industrial phenomena.

For the curiosity driven, fluid mechanics offers the example of a complex system in which the basic equations are known (the Navier-Stokes equations have been known for more than a century) but the resulting behavior is hard to predict and complex. Moreover, the very proof of the existence of solutions escapes researchers leading to such tantalizing problems as those being stated by the Clay Prize.

For the application driven, fluid mechanics has long been the province of aircraft designer, "rocket scientists" or automobile designers. However the recent increase in computer power and algorithmic ingenuity, as well as advances in flow visualization, have opened the field to much more numerous applications such as biological and medical engineering, process and chemical engineering, civil engineering, ocean, nuclear or petroleum engineering. The natural science of geophysics, astrophysics and planetary sciences also heavily rely on fluid mechanics.

Programme learning goals

This master program is jointly operated with Sorbonne University of Paris. It is directed at students preparing for a science or engineering career in academia or industry. Courses all take place during the first semester (September to February). A research project is conducted in France or abroad, in academia or industry, during the second semester (4 to 6 months, March to early July or September). Entering students should have completed undergraduate studies in science with elementary introduction to fluid mechanics.The tables below detail the abilities to be acquired and the expected proficiency levels according to the following grading scale.

Sets of expected abilities	*Expected abilities*	*Expected proficiency level*
		R&D
Disciplinary knowledge and reasoning	**1.1 Knowledge of underlying mathematics and science**	4
	1.2 Core fundamental knowledge of engineering	4
	1.3 Advanced engineering fundamental knowledge, methods and tools	4
Personal and professional skills attributes	**2.1 Analytical reasoning and problem solving**	4
	2.2 Experimentation, investigation and knowledge discovery	4
	2.3 System thinking	3
	2.4 Ethics, though and learning	4
	2.5 Ethics, equity and other responsibilities	4
Interpersonal skills: Teamwork and communication	**3.1 Teamwork**	4
	3.2 Communications	4
	3.3 Communications in foreign language	3
Conceiving, Designing, implementing, operating, innovating and entrepreneurship in the context of Corporate Social Responsibility	**4.1 External, societal and environmental context**	3
	4.2 Enterprise and business context	3
	4.3 Conceiving, systems engineering and management	3
	4.4 Designing	4
	4.5 Implementing	3
	4.6 Operating	3
	4.7 Leading engineering endeavours	4
	4.8 Engineering entrepreneurship	3

More specifically, the **key strengths** of the AA programme are as follows. The graduate will have the capacity to participate in meetings in English with researchers and engineers of international level. He or she will be able to read, understand and analyze a recent scientific paper in the general area of fluid mechanics, to evaluate the relevance of the various approximations needed to solve a problem, to implement the numerical modelling of a fluid phenomenon, through the resolution of the Navier-Stokes equations or more specific models, to propose and evaluated numerical resolution methods using research or commercial Computational Fluid Dynamics (CFD).

Programme structure

Learning outcomes are reached through a well-balanced training program that combines theoretical and practical learning sequences, during which students are placed in both academic and real-life industrial configurations, in order to develop multiple transversal skills

The AA programme is a one-year Master programme (M2) that spreads on two semesters

- **First semester (S1): From September to January**

This semester is composed of 10 scientific modules of 30h each, 1 language module of 30h, for a total of 30 ECTS

- **Second semester (S2): From February to September**
  The second semester is dedicated to the Master thesis of 6 months and 30 ECTS. The internship will be made in a research structure (laboratory or company) in France or abroad.

Code	Title	Sem.	Year	ECTS	Hours	Compulsory/ Optional	Teaching modalities
FF202	Fundamental Aerodynamics	S1	M2	3	30	Compulsory	Course/exercise/project
FF203	Numerical Methods for Compressible Flows	S1	M2	3	30	Compulsory	Course/exercise/project
FF204	Turbulence Dynamics and modelisation	S1	M2	3	30	Compulsory	Course/exercise/project
TF210	Numerical Methods for Incompressible Flows	S1	M2	3	30	Compulsory	Course/exercise/project
TF200	Aeroacoustics	S1	M2	3	30	Optional	Course/exercise/project
TF211	Aeroelasticity	S1	M2	3	30	Optional	Course/exercise/project
TF208	Flow instabilities	S1	M2	3	30	Optional	Course/exercise/project
TF202	High-fidelity Simulation of Compressible Flows	S1	M2	3	30	Optional	Course/exercise/project
TF209	Control theory	S1	M2	3	30	Optional	Course/exercise/project
FF201	Machine learning	S1	M2	3	30	Optional	Course/exercise/project
FF208	Vortices in Hydrodynamics	S1	M2	3	30	Optional	Course/exercise/project
TF212	Optimization in Aerodynamics	S1	M2	3	30	Optional	Course/exercise/project
LV	Advanced technical English	S1	M2	3	30	Compulsory	Language
MT	Internship (Master thesis)	S2	M2	30	5/6 months	Compulsory	Internship

Table 1 : Detail of the modules of the AA programme over the two semesters.

Study and assessment rules

Each module can be evaluated by means of practical works, projects, reports, oral presentations, exams and the assessment rules are explained at the beginning of the programme. Each module is evaluated between 0 and 20.

For professional and language modules (MPi and MLi)

- The final mark of each professional/language module must be ≥ 10, and there is no compensation between the modules

For scientific modules (MSi)

- The final mark of each scientific module must be ≥ 8
- The average of the 10 scientific modules must be ≥ 10, thus there can be compensation between the scientific modules.

For master thesis (MTB and MTI):

- The final mark of the master thesis must be ≥ 10.

Retake exams are organized at the end of the second semester.

Graduation requirements

To be graduated, students need to comply with the following rules:

- Validate 30 ECTS during the first semester
- Validate 30 ECTS during the second semester

At the end of the AA programme, the final average is calculated based on the ECTS distribution, and mentions are awarded (very good, good, fair, passable).

Careers of graduates and access to further studies

Depending on their results and professional expectations, graduate students can continue their professional careers as a:

- PhD student in a field related computational fluid dynamics, in academia or in industry.
- R&D engineer/researcher in large companies or start-ups, in numerous sectors of energy and transports and fields (automotive, aerospace, health, etc.) .